# ENGLISH TRANSLATION OF INTERNATIONAL APPLICATION AS FILED

# DESCRIPTION

# LAMINATED CERAMIC ELECTRONIC PART AND MANUFACTURING METHOD THEREFOR

## Technical Field

The present invention relates to a laminated ceramic electronic part and more particularly to a laminated ceramic electronic part such as an inductor, impedance element, etc., and to a manufacturing method therefor.

## Background Art

Up to now, such a laminated ceramic electronic part described in Patent Document 1 is known. In this electronic part, a spiral coil is formed in such a way that ceramic sheets having coil-forming conductors contained therein are laminated and a pad (land) formed at an end portion of each coil-forming conductor is connected in order through a via hole.

That is, as shown in Fig. 6, a coil-forming conductor 51 is formed on the surface of a ceramic sheet 50 where a hole for via hole is formed by a screen printing method, and at the same time, the hole for via hole is filled with a conductive paste to form a via hole 60. The coil-forming conductor 51 contains a first land 51a where a via hole 60 for connection between layers and a second land 51b to be connected to the via hole 60.

Here, when a condition for screen printing is set to the

first land 51a formed at the position where the hole for via hole is contained or set to the second land 51b where no hole for via hole is contained, there is a problem in that printing defects and insufficient filling are likely to occur at the other land.

For example, as shown in Fig. 7, when the penetration amount of conductive paste 55 in a screen printing plate 66 is increased so that the second land 51b may not have thin spots, the hole for via hole is filled too much with the conductive paste 55 and then the conductive paste 55 is protruded on the back surface of the ceramic sheet. On the other hand, when the fill amount of conductive paste 55 to the hole for via hole is made appropriate, thin spots are likely to occur in the second land 51b having no hole for via hole. This is because the penetration amount of the conductive paste 55 through the screen printing plate 66 is different dependent on whether or not the hole for via hole exists from the viewpoint of characteristics of the screen printing even if the shape of the lands is the same.

In order to prevent the conductive paste 55 from being protruded on the back surface of the ceramic sheet 50 because of the too much fill amount, as shown in Fig. 8, the use of the ceramic sheet 50 backed with a carrier film 52 can be considered. However, a new problem in that the use of the carrier film 52 increases the manufacturing cost is created.

Patent Document 1: Japanese Unexamined Patent Application

Publication No. 2004-87596

## Disclosure of Invention

### Problems to be Solved by the Invention

Then, it is an object of the present invention to provide a laminated ceramic electronic part in which, without making a ceramic sheet backed with a carrier film, appropriate filling in holes for via hole and the prevention of thin spots in lands can stand together and a manufacturing method therefor.

### Means for Solving the Problems

In order to attain the above object, a laminated ceramic electronic part according to the present invention comprises a plurality of ceramic sheets, each having an internal conductor pattern containing a first land at one end of the internal conductor pattern and a second land at the other end and having a via hole formed therein, the plurality of ceramic sheets being laminated to constitute a laminate. In the laminated ceramic electronic part, the via hole is filled with a conductive material, the internal conductor patterns disposed on different layers are electrically connected to each other through the via hole, the first land is contained so as to cover the via hole and the first land contained in one ceramic sheet is electrically connected to the second land contained in another ceramic sheet through the via hole contained in the one ceramic sheet, and the second land is larger than the first land.

It is desirable that the second land be extended from a projection plane of the first land to a projection plane of the coil conductor pattern. Furthermore, it is desirable that the area of the second land be 1.10 to 2.25 times as wide as the area of the first land.

A manufacturing method for a laminated ceramic electronic part according to the present invention comprises the steps of printing an internal conductor pattern having a first land at one end of the internal conductor pattern and a second land at the other end on the surface of a ceramic sheet having a hole for via hole formed therein by using a conductive material in such a way that the first land covers the hole for via hole, filling the conductive material in the hole for via hole, and laminating a plurality of ceramic sheets in such a away that the first land contained in one ceramic sheet is electrically connected to the second land contained in another ceramic sheet through the via hole contained in the one ceramic sheet to obtain a laminate. In the manufacturing method for a laminated ceramic electronic part, the second land is larger than the first land.

It is desirable that the internal conductor pattern is printed on a ceramic sheet having the hole for via hole formed therein and the hole for via hole be filled with a conductive material at the same time, without making the ceramic sheet backed with a carrier film.

Advantages

According to the present invention, since the shape of the second land connected to a via hole in which thin spots are likely to occur at screen printing is enlarged, the discharge amount of conductive paste for forming the second land increases and appropriate filling in the via hole and the prevention of thin spots in the second land can stand together. As a result, a laminated ceramic electronic part in which the reliability and productivity are excellent can be obtained.

In particular, when the area of the second land is made 1.10 or more times as wide as the area of the first land, thin spots in the second land are prevented surely to suppress the problem of electrostatic discharge and the lamination slippage can be prevented. Furthermore, when the area of the second land is made 2.25 or less times as wide as the area of the first land, the reduction in the inductance value can be suppressed.

Brief Description of the Drawings

Fig. 1 is an exploded perspective view showing one embodiment of a laminated ceramic electronic part according to the present invention.

Fig. 2 is a top view of an internal conductor pattern shown in Fig. 1.

Fig. 3 is a sectional view showing the essential part of lamination of the laminated ceramic electronic part shown in Fig.

1.

Fig. 4 is a perspective appearance of the laminated ceramic electronic part shown in Fig. 1.

Fig. 5 is a top view of a modified example of the internal conductor pattern shown in Fig. 1.

Fig. 6 is a top view showing an internal conductor pattern of a related laminated ceramic electronic part.

Fig. 7 is an illustration showing a manufacturing method for a related laminated ceramic electronic part.

Fig. 8 is an illustration showing another manufacturing method for a related laminated ceramic electronic part.

Best Mode for Carrying Out the Invention

Hereinafter, embodiments of a laminated ceramic electronic part and a manufacturing method therefor according to the present invention are described with reference to the accompanied drawings. In the following embodiments, a laminated inductor is described as an example, but a laminated impedance element and a laminated LC composite part may be used instead.

As shown in Fig. 1, a laminated inductor 1 is constituted by ceramic green sheets 2 in which coil conductor patterns 3 to 7, lead-out electrodes 8 and 9, and via holes 15 are contained, external ceramic green sheets 2a not having conductor patterns contained in advance, etc.

The ceramic green sheets 2 and 2a are produced by the

following method. Various raw powders such as raw ferrite powders NiO, CuO, ZnO, $Fe_2O_3$, etc., are wet-mixed by a ball mill, etc., and dried by a spray dryer, etc., and then, calcined. The obtained ferrite powders are dispersed in a solvent and the ceramic slurry is adjusted. Then, molding is performed using the ceramic slurry by a doctor-blade method to obtain a long ceramic green sheet. A ceramic green sheet of a fixed size is stamped out from the long ceramic sheet and, as required, hole for via hole are formed and then, a ceramic green sheet 2 is produced.

Next, coil conductor patterns 3 to 7 and lead-out electrodes 8 and 9 are formed on each ceramic green sheet 2 by a screen-printing method and simultaneously a conductive paste is filled in the holes for via hole to form via holes 15. A direction of squeegee travel is set to be a direction as shown in Fig. 2 with reference to the coil conductor pattern, for example. At this time, the coil conductor patterns 3 to 7 etc., are printed and simultaneously the via holes 15 are formed on the ceramic green sheets 2 having the holes for via hole formed therein while the ceramic green sheets are not backed with a carrier film.

That is, on the surface of the ceramic green sheet 2 shown in Fig. 2, a first land 4a is printed by using a conductive paste so as to cover the hole for via hole and simultaneously the conductive paste is filled in the hole for via hole. Accordingly, the coil conductor pattern 4 contains lands of two kinds of a

first land 4a having the via hole 15 for connection between layers and a second land 4b connected to the via hole 15. Then, the second land 4b is made larger in diameter than the first land 4a.

That is, the coil conductor patterns 3 to 7 contain the lands of two kinds of first lands 3a to 6a having the via holes 15 for connection between layers and second lands 4b to 7b connected to the vial holes 15. Then, the second lands 4b to 7b are larger in diameter than the first lands 3a to 7a.

Furthermore, the lead-out portion of the coil conductor pattern 3 is connected to the lead-out electrode 8 formed on the left side of the sheet 2. The lead-out portion of the coil conductor pattern 7 is connected to the lead-out electrode 9 formed on the right side of the sheet 2.

Each ceramic green sheet 2 is laminated and the external ceramic green sheets 2a are disposed on the top and bottom of that. Then, that is pressed at 1,000 kgf/cm$^2$ to form a laminated block. In this way, the coil conductor patterns 3 to 7 are electrically connected by the via holes 15 and a spiral coil is formed. As shown as one example in Fig. 3, the connection of the conductor patterns is performed in such a way that a first land 4a contained in a sheet 2(x) and a second land 5b contained in a lower sheet 2(y) are electrically connected through a via hole 15.

After the above-described laminated block has been cut to a

fixed size, the laminated block is degreased and integrally burnt at 870°C. Thus, a laminate 20 shown in Fig. 4 is made.

Next, external electrodes 21 and 22 are formed in such a way that a conductive paste is applied to both end portions of the laminate 20 and it is baked at 850°C. The external electrode 21 is electrically connected to the lead-out electrode 8 and the external electrode 22 is electrically connected to the lead-out electrode 9.

In the laminated inductor 1 having the above-described structure, since the shape of the second lands 4b, 5b, 6b, and 7b connected to the vial holes 15 in which thin spots easily occur at the time of the screen printing is enlarged, the discharge amount of conductive paste for forming the second lands 4b to 7b increases. Accordingly, regarding the condition of the screen printing, even if the fill amount of conductive paste to the holes for via hole is made appropriate in accordance with the first lands 3a to 6a formed at the locations having the holes for via hole formed, the occurrence of thin spots becomes hard in the second lands 4b to 7b. That is, the appropriate filling to the via holes 15 and the prevention of thin spots in the second lands 4b to 7b can stand together. As a result, a laminated inductor 1 excellent in the reliability and productivity can be obtained.

Table 1 shows the evaluation result of the obtained laminated inductor 1 (Embodiment 1). The diameter of the via

holes is 160 μm, the diameter of the first lands 3a, 4a, 5a, and 6a is 200 μm, and the diameter of the second lands 4b, 5b, 6b, and 7b are set to be 240 μm. For comparison, in Table 1, the evaluation result of the related laminated inductors having the coil conductor pattern 51 shown in Fig. 6 is also contained together. In the related laminated inductors, the first land 51a having the via hole 60 and the second land 51b connected to the via hole 60 each are 200 μm in diameter (Comparative example 1) and are also set to be 240 μm in diameter (Comparative example 2). The inductance value is a average value of sample number 30 and the rejected number in an electrostatic discharge test is shown when a contact discharge is performed applying a voltage of ± 30 kV, ten times for each voltage, at an interval of 0.1 sec to the samples of sample number 30 by using an electrostatic discharge gun. The maximum lamination slippage is obtained by magnifying the vertical section of the laminated inductor using a microscope and performing the structural analysis of that.

Table 1

| | Coil conductor pattern | | Evaluation result | | |
|---|---|---|---|---|---|
| | Second land | First land | Inductance value | Electrostatic discharge test Rejection number | Maximum lamination slippage |
| Embodiment 1 | 240 μm | 200 μm | 9.8 μH | 0/30 | 15 μm |
| Comparative example 1 | 200 μm | 200 μm | 10.3 μH | 2/30 | 14 μm |
| Comparative example 2 | 240 μm | 240 μm | 9.5 μH | 0/30 | 55 μm |

When the cause of the rejection in the electrostatic discharge test of Comparative example 1 was investigated, it was found that the rejection resulted from printing defects (printing thin spots) of the second land 51b. Furthermore, when the cause of the increased lamination slippage in Comparative example 2 was investigated, it was found that, since the fill amount of conductive paste to the hole for via hole was too much at printing and the conductive paste was protruded on the back surface of the ceramic green sheet, the lamination slippage occurred.

Furthermore, as shown in Fig. 5, a coil conductor pattern 34 in which a second land 34b is substantially equal in diameter to a first land 34a and the second land 34b is extended from a projection plane of the first land to a projection plane of the coil conductor pattern may be used. In this way, the shape of the top view of a spiral coil formed by the coil conductor

patterns becomes equal to the spiral coil of the related laminated inductor and, since the inner area of the coil does not change, the inductance value and the high-frequency characteristics do not change.

Table 2 shows the evaluation result of a laminated inductor having the coil conductor pattern 34 shown in Fig. 5 (Embodiment 2). Here, the second land 34b is equal in diameter to the first land 34a, and the second land 34b is lengthened in the amount of L = 100 μm from a projection plane of the first land to a projection plane of the coil conductor pattern (that is, in a direction where the extended portion is hidden when projection is performed in the lamination direction). In this evaluation experiment, a conductive paste having a coefficient of viscosity of 100 Pa·s is screen printed by using a printing plate of opening ratio 60%.

For comparison, in Table 2, the evaluation result of the laminated inductor 1 having the coil conductor pattern 4 shown in Fig. 2 (the above-described embodiment 1) and the evaluation result of the related laminated inductor having the coil conductor pattern 51 shown in Fig. 6 (the above-described Comparative 1) are contained together.

Table 2

| | Coil conductor pattern | | Evaluation result | | |
|---|---|---|---|---|---|
| | Second land | First land | Inductance value | Electrostatic discharge test Rejection number | Maximum lamination slippage |
| Embodiment 2 | 100 μm* | 200 μm | 10.2 μH | 0/30 | 15 μm |
| Embodiment 1 | 240 μm | 200 μm | 9.8 μH | 0/30 | 15 μm |
| Comparative example 1 | 200 μm | 200 μm | 10.3 μH | 2/30 | 14 μm |

* 100 μm extended in a direction where the extended portion is hidden at projection in the lamination direction

In the case of the laminated inductor 1 of the Embodiment 1, since the diameter of the second lands 4b to 7b is made larger, the area inside the coil is reduced and the inductance value is a little lowered in comparison with the related one, but the inductance value of the laminated inductor of the Embodiment 2 has little changed.

Next, Table 3 shows the evaluation result of test samples 1 to 7 each in which the diameter (area) of the first land and the second land each are changed. The content of the evaluation test is the same as that in the above-described Tables 1 and 2. The test samples 1 to 5 are prototyped in such a way that, although the diameter of the first land is 200 μm, the diameter of the second land is changed so as to be 205, 210, 220, 300, and 320 μm. The test samples 2 to 4 are accepted in the electrostatic

discharge test, their inductance value is also desirable, and their lamination slippage is small. On the other hand, in the test sample 1 (the area ratio is 1.05), some showed printing defects (printing thin spots)and were rejected. In the test sample 5 (the area ratio is 2.56), the second land was made larger and the inductance value was lowered.

Furthermore, the test samples 6 and 7 were prototyped in such a way that, although the diameter of the second land was 220 μm, the diameter of the first land was changed so as to be 210 and 215 μm. The evaluation result of the test sample 6 was desirable, but, in the test sample 7, the fill amount of conductive paste to the hole for via hole formed in the first land was much and the lamination slippage increased.

Table 3

| Test sample | Coil conductor pattern | | | | | Evaluation result | | |
|---|---|---|---|---|---|---|---|---|
| | Second land | | First land | | Area ratio (Second land/First land) | Inductance value | Electrostatic discharge test Rejection number | Maximum lamination slippage |
| | Diameter | Area | Diameter | Area | | | | |
| 1* | 205 μm | 33006 μm² | 200 μm | 31416 μm² | 1.05 | 10.4 μH | 1/30 | 14 μm |
| 2 | 210 μm | 34636 μm² | 200 μm | 31416 μm² | 1.10 | 10.2 μH | 0/30 | 16 μm |
| 3 | 220 μm | 38013 μm² | 200 μm | 31416 μm² | 1.21 | 10.1 μH | 0/30 | 15 μm |
| 4 | 300 μm | 70686 μm² | 200 μm | 31416 μm² | 2.25 | 9.5 μH | 0/30 | 15 μm |
| 5* | 320 μm | 80425 μm² | 200 μm | 31416 μm² | 2.56 | 9.2 μH | 0/30 | 15 μm |
| 6 | 220 μm | 38013 μm² | 210 μm | 34636 μm² | 1.10 | 10.1 μH | 0/30 | 16 μm |
| 7* | 220 μm | 38013 μm² | 215 μm | 36305 μm² | 1.05 | 10.1 μH | 0/30 | 35 μm |

Moreover, the present invention is not limited to the above-described embodiments and it is to be understood that changes and modifications may be made without departing from the spirit or scope of the present invention.

Industrial Applicability

As described above, the present invention is useful for a laminated ceramic electronic part such as an inductor, impedance element, etc., and a manufacturing method therefor, and in particular, the invention is excellent in that, without making a ceramic green sheet backed with a carrier film, appropriate filling to a via hole and the prevention of thin spots in a land can stand together.